Department of Defense

Legacy Resource Management Program

Legacy Project # 14-750

Cooperative Agreement # W9132T-14-2-0024

Demonstrating How Vulnerability Assessments Can Support Military Readiness

Task #6 Final Report

November 25, 2015

1 Table of Contents

2 INTRODUCTION

This is the final report under the FY14 Department of Defense (DoD) Legacy Program funded project titled "Demonstrating How Vulnerability Assessments Can Support Military Readiness" (Project # 14-750, Contract # W9132T-14-2-0024). This report summarizes the findings, lessons learned, and recommended next steps for this project.

Military installations face many challenges that impact their ability to carry out their military mission. An increase in land use and development, water resource constraints, climate change impacts, and declining species and associated ecological systems are impacting Department of Defense (DoD) inside and outside their installation boundaries. More and more, a regional, multi-stakeholder approach to planning and land management is the only way to continue to preserve lands for military training and testing activities. To address species protection requirements at this regional scale, the military needs to know where species occur and how they are doing on and off military lands. In addition, knowing where at-risk species potentially occur or could be protected or restored is critical to the long-term success of balancing military and natural resource needs.

The overall goal of this project was to demonstrate standard methods for assessing known and potential impacts on select species for areas on and around three DoD installations (Eglin Air Force Base, Boardman Navel Weapons Systems Training Facility, and Fort Huachuca Military Reservation), and develop recommendations to address those impacts. These methods support preventing the decline of species and thus reduce the impacts to military training operations through a better understanding of the full extent of potential impacts, and range of successful conservation management strategies that can be applied to high priority imperiled species.

To achieve the project goal the project team worked with installation staff to first select a few high priority species that are imperiled and of concern to the installation due to the fact that these species could impact military activities (hereinafter "species of interest"). Then the team ran species distribution models (SDMs) for the species of interest to identify where they are known to occur, and where there is a high probability of occurrence in and around the installation. Next, the team integrated the SDM results with various land use and land management data layers, and information on the degree of impact each land use may have on each species of interest based on expertise from project team. This led to the identification of areas of conflict between the species of interest and land use. Based on this conflict analysis, the team was able to determine the vulnerability of each species in the region, and where there are opportunities for conservation and mitigation in and around the installations. This informed the development of management recommendations for areas within and around the three installations that can be used to facilitate a dialog between DoD and other land management agencies and organizations to address regional conservation needs.

3 Findings and Lessons Learned

3.1 Predictive Species Distribution Modeling

Under this project, the team evaluated the application of a specific approach to developing species distribution models (SDMs) at Eglin Air Force Base (Eglin AFB), Boardman Navel Weapons Systems Training Facility (Boardman NWSTF), and Fort Huachuca Military Reservation (Fort Huachuca). This approach included the consistent application of random forest modeling, and access to local biological conservation experts and a precise expert-reviewed species dataset. The purpose of the modeling efforts was to demonstrate the modeling approach's accuracy and transferability to other DoD installations across the U.S.

The project team was led by NatureServe, in collaboration with its member programs in Arizona, Florida, New York, and Oregon (Arizona Heritage Data Management System, Florida Natural Areas Inventory, New York Natural Heritage Program, and Oregon Biodiversity Information Center respectively). The team embodied both the technical skills and biological expertise needed to build and evaluate SDMs. Two staff, one from Oregon and one from New York, had the most experience in using these modeling techniques to model rare and imperiled species. These two staff provided leadership and training to the rest of the team on the modeling process. Biological experts from Arizona, Oregon and Florida provided input to the technical team at several points during the modeling process including identification of environmental variables that could be used an indicator of a species presence, and evaluation of draft models including assistance with decisions regarding error-tradeoffs in the final maps. Despite the concern that modeling informed by 'expert knowledge' comes with potential challenges in achieving truly objective results (McBride et al. 2012), expert input is often an invaluable resource in accurately modeling at-risk species, especially when comprehensive empirical datasets are limited (Martin et al. 2012), and for the inherently subjective step of cutoff selection (Loiselle et al. 2003).

Boardman NWSTF staff in collaboration with the project team chose to model the Washington Ground Squirrel (Urocitellus washingtoni), Western Burrowing Owl (Athene cunicularia hypugaea), and Laurence's Milk-vetch (Astragalus collinus var. laurentii). Installation staff at Fort Huachuca chose Lemon Lily (Lilium parryi), Huachuca Water-umbel (Lilaeopsis schaffneriana ssp. recurva), Arizona Ridge-nosed Rattlesnake (Crotalus willardi willardi), Arizona Treefrog (Hyla wrightorum), and Huachuca Springsnail (Pyrgulopsis thompsoni). The Eglin AFB team chose the Panhandle Lily (Lilium iridollae), Gopher Tortoise (Gopherus polyphemus), Florida Bog Frog (Lithobates okaloosae), Small-flowered Meadow-beauty (Rhexia parviflora), and Panhandle Meadow-beauty (Rhexia salicifolia).

Overall, the process of building a distribution model involved: 1) compiling data on known species locations, and also the environment in the defined area of interest; 2) building a model associating species presence with environmental variables; and 3) mapping predictions across the area of interest. This process was iterative, and involved biological expert evaluation of interim draft maps. Because each region was modeled by a different team, we used a standardized set of scripts for model building, promoting consistency, while allowing for local modifications.

We built SDMs with the random forest machine learning algorithm (Breiman 2001), as it is implemented by the randomForest package (Liaw & Wiener 2002) in the R environment for statistical computing (R Development Core Team 2013). This algorithm is becoming more widely used in the field of ecology (Cutler et al. 2007). It is a flexible and robust technique, minimizing problems with data irregularities such as collinearity. It is also a relatively complex model, which makes it less effective for ecological understanding, but appropriate for this application where prediction accuracy is the primary goal (Merow et al. 2014). Also, this model has proved effective for mapping rare plant species (Williams et al. 2009).

We evaluated our models and maps through four different steps: 1) Characterizing overall strength for discerning presence and background points, 2) Visual review of mapped products with biological experts, and binary cutoff selection. 3) Error structure assessment of binary transformations of the model predictions, and 4) Tabulating area identified as habitat within the binary maps.

A major factor that contributed to the accuracy of the models was the data used. The primary dataset used in the modeling was NatureServe member program species location data, also referred to as Element Occurrence or EO data. These data are specifically designed and maintained to help support localized conservation decisions. Unlike many publically available species observation databases, NatureServe EO data undergo considerable quality control that makes them particularly well-suited for habitat distribution modeling. Specifically, observational polygons or EOs are constructed to represent areas with practical conservation value. For example, an observation of the Arizona Ridge-nosed Rattlesnake dead on a road could indicate the need for survey work nearby, but it would not be documented as an EO, since a road is not an area of practical conservation value. An example of an Arizona Ridge-nosed Rattlesnake EO could be among other things an observation of one or more individuals in or near appropriate habitat such as a fallen log. Moreover, if there are uncertainties in the documented locations of an EO standard buffering protocols are applied. The resultant polygons are further reviewed by local experts, and modified so that they do not include obvious areas not suited to the species (e.g., golf courses, roads, etc.). Thus use of this highly accurate and comprehensive species location data increased the accuracy of the models. Furthermore, we found that using data and expertise from NatureServe and its member programs in Arizona, Florida, and Oregon increased the species location data samples available and the resulting precision of the distribution models, and the models underwent a standard accuracy validation process to verify this fact.

The models with the highest accuracy corresponded to areas where the data was more comprehensive - in this case the area around Boardman NWSTF. But the data was also very good in the area around Fort Huachuca because a lot of very refined data were available due to work done under another project in that area in collaboration with the Bureau of Land Management. The climate and imagery data for the Florida/Georgia region was not available to the precision that is was in the other two regions, and so that impacted the accuracy of the modeling results in that region. Some of the species we modeled were more challenging to model than others either because they are found over a wide range of habitats over a large area like the gopher tortoise, or because they have a very narrow habitat that is hard to locate using current imagery data. But even with these challenges, our results were strong and in line with other studies that find consistently strong results in SDM exercises with diverse geographies and taxa (e.g., Elith et al 2006), and also studies that indicate strong performance for the random forest algorithm for rare species (Williams et al. 2009).

But despite that fact that the three sites where the modeling occurred encompassed a wide range of environmental conditions, that we modeled a diverse suite of species, and that we had some variability in precision of datasets, our consistent methodology worked well at all three sites. This illustrates the transferability of the methods used.

Overall, the project team found that the use of comprehensive and high quality species data, species conservation experts, and consistent modeling methods that are well suited to modeling rare and imperiled species provided very accurate results that can be adopted for use in regional conservation planning efforts across the U.S. Figure 1 is an example of the SDM output for the Washington Ground Squirrel.

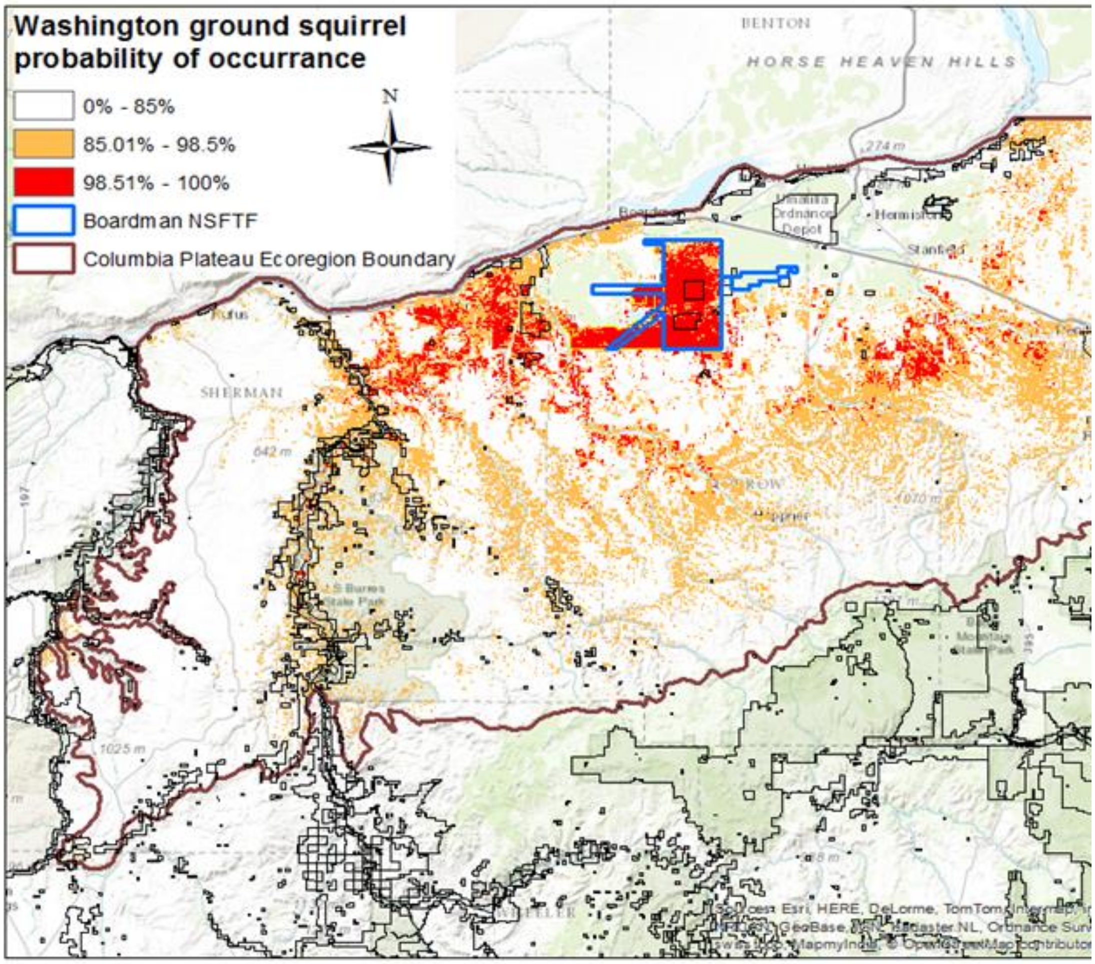

Figure 1: Predictive distribution map for the Washington Ground Squirrel. Red areas indicate where the species is most likely to occur.

The overall modeling process took longer than we expected and caused major delays in the overall project since the results of this work fed into all the other deliverables. The process of getting access to all the various climate and imagery data at the finest resolution available was a major task but important for modeling rare and at-risk species. In addition, regional-scale modeling requires data preparation including “stitching” images together and other types of data reconciliation especially across jurisdictional borders. Although we did provide the sub-teams with guidance on the types of data needed, in future modeling efforts assigning a central lead on this task that works across all the regions and has expertise in acquiring and preparing data would have helped move this task along more quickly. The other challenge was that the primary person in charge of modeling and guiding other members on the team in modeling was out of the country after the initial modeling was completed, and so was not as available to help the local experts review and refine the models which is an essential part of the modeling process when modeling rare and imperiled species. So it is critical for future efforts to ensure sufficient time and access to all the expertise needed not only to acquire and prepare the data, but oversee the entire process from modeling, to review and refinement of models based on expert input.

3.2 Vulnerability Assessment

The purpose of the vulnerability assessment was to provide an understanding of: 1) the current vulnerability status of species of interest, 2) which stressors are primarily responsible for current status and where, and 3) the potential future status of the conservation features in relation to projections of stressors into the future. Status is a measure of the condition or quality of the species habitats as depicted in the modeled distributions as well as their known locations. Understanding where stressors or other features are that appear to be compromising species habitats (hereafter referred to as conservation elements, abbreviated as CEs), as well as the location and degree of potential future impacts, can inform the development of conservation strategies designed to eliminate or mitigate such impacts.

The project team integrated the predictive modeling results with many land use and land management data layers into the decision support tool NatureServe Vista. It is specifically designed to support a regional analysis of land use and land management effects on species conservation goals. This analysis provided information on the degree of impact each land use could have on each at-risk species, leading to the identification of areas of conflict and areas of mitigation opportunities. Figure 2 shows the results of the vulnerability assessment for the Ridge-nosed Rattlesnake in and around Fort Huachuca. Based on the vulnerability assessment results, the team was able to work with DoD staff to determine where threats or opportunities for recovery are located in and around the installations.

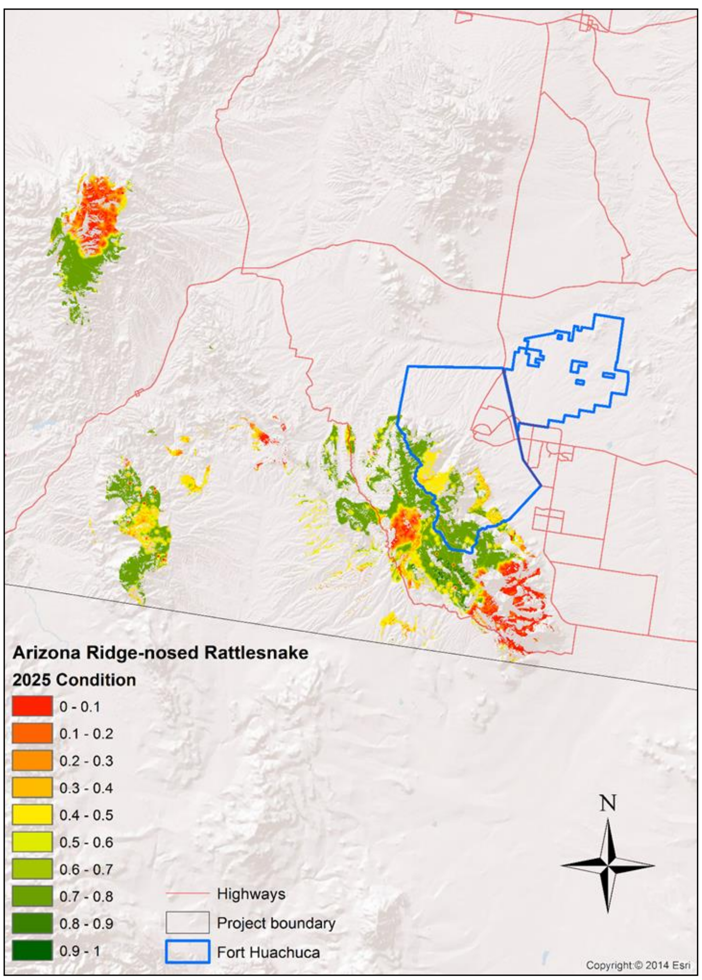

Figure 2: Arizona Ridge-nosed Rattlesnake Vulnerability Score Map for area in and around Fort Huachuca. Red indicates the most vulnerable areas.

Spatial data sets reflecting stressors or other features affecting the condition of the CEs were aggregated by team members to create indicator "scenarios." For example, numerous spatial datasets representing roads, mine locations, transmission lines, oil and gas development, landfills, agricultural cropland, and others were combined into a single development indicator scenario. These scenarios were compiled and evaluated in NatureServe Vista, using NatureServe's Landscape Condition Model (LCM) (Comer and Faber-Langendoen 2013, Comer and Hak 2009), to score the indicators for each species and characterize its vulnerability status. A "response model" characterizing how a species responds to each of the stressors or other features reflected in the scenarios was a key input into the LCM. For example, a species may have a very negative response to major roads, but only a moderately negative response to low density urban land use. For each stressor-based scenario (e.g., development, invasives, fire, etc.), the LCM generates a raster reflecting the condition score for each of the CE's indicators. Vista was then used to generate a raster characterizing the overall vulnerability status of the CE, by combining the individual indicator results. Scores for vulnerability status are on a continuous scale ranging from 0 to 1, with 0 being the most highly altered, and 1 being closest to reference conditions.

For each species included in this project, a map showing the areas where the species was more or less vulnerable to current and future threats was generated using the methods described above. Each regional sub-team (i.e. Florida, Oregon and Arizona) met with the NatureServe staff who created the various indicator scenarios in order to explore various sites for potential conservation or restoration opportunities. After these meetings, NatureServe and staff from the three NatureServe member programs met with installation staff to discuss these results. These discussions guided by the NatureServe Vista scenarios and the expertise of each installation and NatureServe member programs in Florida, Oregon and Arizona, resulted in the recommendations that were made in each installation report.

It would be interesting to conduct the type of analyses that was done on and around Boardman, for the Washington Ground Squirrel and the Western Burrowing Owl, for other co-occurring species and geographic areas. The locations of Western Burrowing Owl coincide with the Ground Squirrel because it depends on the squirrel for nesting sites. Since these two species occur in the same habitat, overlapping data for these two species allowed us to see the areas where these species are potentially co-occurring, and the level of threat to each area thus helping to target areas for conservation or restoration that benefit both species. This type of analyses could be done for other groups of species occurring in similar habitat to target areas that would bring the most conservation benefit to multiple species.

As with the modeling, the most challenging aspect of the vulnerability assessment effort was getting access to the best available data on current and future threats and other information that could indicate the vulnerability of a species. Once the process of acquiring the data was completed, the regional experts in the NatureServe member programs in Arizona, Florida and Oregon had to review how each threat would effect each individual species before the Vista scenarios could be created. Once these two tasks were completed, running the scenarios was relatively quick and straight forward. The final step was for the local team members to meet with the staff at NatureServe who created the Vista scenarios in order to explore specific sites for conservation or restoration potential, and inform the final task of developing conservation management recommendations. Results of the SDMs and vulnerability status assessments were then presented via webinar to DoD installation staff to help guide the final task of developing conservation strategies.

3.3 Conservation Management Strategies

Conservation strategies identify where conservation actions can be taken and what mitigation or management actions may be effective for reaching retention goals for the species in light of the vulnerability assessment results.

Developing complete, implementable conservation strategies is a complex endeavor that can take considerable time and resources. Since this project was a demonstration project that only included a few key species, strategy development potential was limited and recommendations were more descriptive. In this project, the team completed the vulnerability assessment and then made some general conservation strategy recommendations based on expertise of the team and the assessment results. These recommended strategies would need to be further fleshed out and spatially defined in Vista to see how various conservation strategies might affect the overall vulnerability status of the species included in the analyses. Since NatureServe will be making the Vista software and data used in the analyses available to the installations, with some additional support the installations staff could use Vista to support consideration and implementation of various conservation strategies in collaboration with partners in and around the installation.

The following describes two different strategy contexts and proposed approaches for developing conservation solutions that could be implemented in follow on work.

The use of decision support tools (NatureServe's Vista and Marxan) could be used to generate spatially explicit conservation solutions from sites to entire landscapes.

There are two general situations under which conservation strategies are developed:

- Limited conflict: in these cases, a sufficiently small number of impacted occurrences of the CEs (those falling below the condition threshold) are identified where individual investigation and responses can be formulated to meet the conservation (or retention) goals for the species. This can address onsite and off-site mitigation of stressors and conservation.
- Systemic conflicts: in these cases, conflicts are widespread in the assessment area, making it impractical to investigate each species occurrence individually and formulate an efficient strategy for reaching retention goals. An optimization model (such as Marxan or Zonation) is needed to quickly identify efficient sets of occurrences to focus on. Optimization models utilize the same information contained in the Vista DSS to run millions of iterations, honing in on most-efficient solution sets. Optimization requires a "cost" factor to optimize on which can be actual acquisition cost, degree of threat/habitat condition, or simply the acres of land needed. Note, however, that when species retention goals are set to 100% (e.g., for highly imperiled species), optimization is unnecessary because all occurrences must be included in reaching the retention goal. In that case, all occurrences of the species are in the conservation solution set.

Depending on whether conflict is limited or systemic, different approaches for identifying strategies are used. Where conflict is limited, Vista's "Conflict Compatibility" map is used to iteratively identify sites preventing the achievement of species' conservation or retention goals. Vista's Site Explorer function is used to identify which stressors (from the indicator scenarios) are affecting the CEs at the site, and land ownership may be viewed to determine what kind of strategies may be feasible and appropriate. Based on the stressors affecting the species at the site, and the land ownership, relevant conservation strategies (e.g., "invasive species treatment" or "REPI program easement") are selected and applied in Vista to test how their application will affect the goal achievement for the species. These steps are repeated site by site and strategy by strategy until the desired level of mitigation and goal retention is attained. The identified strategies are then combined into an alternative scenario in Vista, and the LCM is run to confirm that CE viability and representation goals are reached or to reveal additional areas for action.

Where conflict is systemic, the optimization model Marxan is used in conjunction with Vista to identify appropriate strategies. Vista has an interoperation wizard to package the inputs for Marxan which is then run and results are imported back to Vista to guide development of a network of conservation solutions. The Marxan tool runs millions of iterations to hone in on a “near optimal” spatial solution of units capable of meeting CE representation goals subject to other criteria specified by the user such as cost limits and how clumped the solution needs to be. The “sum of runs” output informs what percent of the runs a particular site is selected for the solution that provides a measure of how “irreplaceable” that site is for meeting CE representation goals. Marxan, however, does not guide specification of what to do on each site nor what implementation mechanism to use; those attributes are developed within Vista’s Site Explorer. Vista can also be used to evaluate the Marxan solution for CE viability since it can evaluate data at a scale appropriate to assess viability along with other objectives such as habitat adjacency and connectivity for species life history needs.

4 Recommendations and Next Steps

This project clearly demonstrates that developing range-wide or ecoregion-wide species distribution models (SDMs) can significantly inform both restoration and mitigation opportunities, as well as areas which potentially need to be inventoried for the species. Because many imperiled species occurring on installations across the U.S. also occur outside installation boundaries, existing and future expansion of training will likely create the need for some off-site mitigation in addition to mitigation actions inside the installation boundaries. This project demonstrated that SDMs can both help identify a number of potential off-base mitigation sites, as well as to assist the installations and wildlife agencies in locating sites that can support multiple species of interest, like the example of the Washington ground squirrel and the burrowing owl described above.

As mentioned, follow-on work could include a larger suite of species and explore species that co-occur in similar habitats supporting knowledge on where these species potentially occur and where there are potential threats. This information would be helpful in targeting areas for conservation or restoration that could benefit more than one species and result in a more significant conservation benefits. This multi-species, landscape scale approach is certainly one that all the U.S. federal agencies are adopting. So following-up this project with the same type of modeling, analyses and recommendations for the full suite of imperiled species occurring on and around the participating installations and other priority installations across the U.S. would help determine the role of DoD and the role of other land management agencies in conducting conservation and or restoration programs.

The vulnerability assessment aided in the evaluation of long-term threats and viability of the known and potential locations of target species both on and off the installation that further inform the identification of areas where there is the potential for conservation and restoration action. For example, identifying of areas that do not have a high degree of vulnerability could be explored as better potential locations for translocation, mitigation or restoration. The Vista decision support system (DSS) has functions to support investigating individual sites and testing proposed actions for benefits and conflicts. Integrating the SDMs and vulnerability assessment into a DSS that can be used by installation staff has the potential to make assessments relatively simple and routine and also support a number of additional applications as described below.

- Within-installation assessment and management can be supported by proposing site-based actions (either training or land management for example) and receiving immediate reports of conflicts and benefits.
- Complete Installation Resource Management Plans can be created in the DSS that can facilitate meeting training and stewardship objectives while avoiding conflicts between them.
- Offsite/landscape assessments and planning can be conducted to support programs such as Joint Land Use Study, Readiness and Environmental Protection Integration Program, and other regional planning efforts.
- While the pilot study did not integrate climate change impacts, the data developed, both in the SDMs and in the NatureServe Vista DSS provide DoD with the opportunity to relatively quickly integrate and explore potential climate change impacts to the critical species and the habitats that support them. This can include phased planning to retain viable species populations in their present locations and using mitigation funds to retain climate refugia areas in the future.

The software used in the project to develop the SDM is open source and in the public domain, and Vista is a freely available extension to ArcGIS. These tools can be used for any future assessment and planning needs of the natural resources staff at the participating installations. The SDM models, data, and Vista ArcMap project have been offered to the participating installation staff, and training in the use of the Vista DSS is available.

Another follow-up effort could be the development of technical guidelines and corresponding online training modules for conducting this type of modeling and vulnerability assessments in order to assist installations in conducting this type of work on the installation and in collaboration with other agencies and organizations. There could also be a follow-up effort to expand the analyses for the current areas, or new areas, to include the types of analyses described above for a wider suite of species, and then assist installations in the creation of an actionable regional conservation management strategy in partnership with other agencies.

5 KEY TERMS

The following are key terms and abbreviations used throughout this document.

Condition: used interchangeably with Status (see below)

Condition threshold: the minimum condition score an occurrence must achieve to be considered of viable quality.

Conservation Element (CE): This is the generic term used in the decision support system that was used for the vulnerability assessment and conservation strategies. In the case of this project, it refers to the species that were modeled and assessed.

Indicator: Specific, measurable indicators are used to assess the status of specific characteristics of a species' or ecosystem's biology, ecology, or physical environment that is critical to the resource's persistence in the face of both natural and human-caused disturbance.

Minimum occurrence size: the area a patch/occurrence must be to be considered viable, subject to condition threshold.

Retention goal: this is the amount (percent or quantity) of a species' distribution that should be retained to maintain a viable amount of habitat in the assessment area, subject to minimum occurrence size and condition threshold.

Scenario: The aggregation of spatial datasets containing distributions of stressors that, combined, are indicators for specific characteristics of a species' or ecosystem's biology, ecology, or physical environment that is critical to the resource's persistence in the face of both natural and human-caused disturbance. Scenarios can also contain features that maintain CE status such as protected areas with conservation land use or compatible management.

Status: ecological status or condition of areas of a conservation element's distribution based on presumed effects of change agents on the CE

Stressor: These are the features or processes that can negatively impact Conservation Elements (and in some cases can have neutral or beneficial effects on certain Conservation Elements).

Viable/Viability: in this assessment, viability for a species is defined as meeting the retention goal (quantity) of habitat that meets minimum patch/occurrence size requirements and meets or exceeds the condition threshold.

6 LITERATURE CITED

Breiman L (2001) Random forests. Machine Learning 45:5–32.

Comer, P.J. and J. Hak. 2009. NatureServe Landscape Condition Model. Technical documentation for NatureServe Vista decision support software engineering. NatureServe, Boulder CO.

Comer, P. and D. Faber-Langendoen. 2013. Assessing Ecological Integrity of Wetlands from National to Local Scales: Exploring the Predictive Power, and Limitations, of Spatial Models. National Wetlands Newsletter Special Issue on Wetland Mapping and Assessment. Environmental Law Institute. Washington DC. Vol. 35 No. 3 May/June 2013.

Cutler DR, Edwards Jr TC, Beard KH, Cutler A, Hess KT, Gibson J, Lawler JJ (2007) Random forests for classification in ecology. Ecology 88:2783–2792.

Elith J, Graham H, Anderson P, Dudik M, Ferrier S, Guisan A, Hijmans J, Huettmann F, Leathwick R, Lehmann A, Li J, Lohmann G, Loiselle A, Manion G, Moritz C, Nakamura M, Nakazawa Y, Overton CM, Townsend Peterson A, Phillips J, Richardson K, Scachetti-Pereira R, Schapire E, Soberon J, Williams S, Wisz S, Zimmermann E (2006) Novel methods improve prediction of species' distributions from occurrence data. Ecography 29:129–151.

Faber-Langendoen, D., J. Rocchio, M. Schafale, C. Nordman, M. Pyne, J. Teague, T. Foti, and P. Comer. 2006. Ecological Integrity Assessment and Performance Measures for Wetland Mitigation. Final Report to US EPA Office of Water and Wetlands. NatureServe, Arlington, VA.

Liaw A, Wiener M (2002) Classification and regression by randomForest. R News 2:18–22.

Loiselle BA, Howell CA, Graham CH, Goerck JM, Brooks T, Smith KG, Williams PH (2003) Avoiding Pitfalls of Using Species Distribution Models in Conservation Planning. Conservation Biology 17:1591–1600.

Martin TG, Burgman MA, Fidler F, Kuhnert PM, Low-Choy S, Mcbride M, Mengersen K (2012) Eliciting Expert Knowledge in Conservation Science. Conservation Biology 26:29–38.

Merow C, Smith MJ, Edwards TC, Guisan A, McMahon SM, Normand S, Thuiller W, Wüest RO, Zimmermann NE, Elith J (2014) What do we gain from simplicity versus complexity in species distribution models? Ecography 37:1267–1281.

McBride MF, Fidler F, Burgman MA (2012) Evaluating the accuracy and calibration of expert predictions under uncertainty: predicting the outcomes of ecological research. Diversity and Distributions 18:782–794.

R Development Core Team (2013) R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria.

Williams, J.N, C. Seo, J. Thorne, J.K. Nelson, S. Erwin, J.M. O'Brien, and M.W. Schwartz. 2009. Using species distribution models to predict new occurrences for rare plants. Diversity and Distributions 15: 565-576.